MULTI-EPOCH UBVRcIc PHOTOMETRIC CATALOG OF SYMBIOTIC STARS

Arne Henden[1] and Ulisse Munari[2]

[1] *AAVSO, 49 Bay State Road, Cambridge, MA, USA*

[2] *INAF Osservatorio Astronomico di Padova, via dell'Osservatorio 8, 36012 Asiago (VI), Italy*

Abstract.
We present a multi-epoch, accurate UBVRcIc photometric catalog of 83 symbiotic stars and related objects, measured while calibrating the Henden and Munari (2000, 2001, 2006) photometric sequences around them. The vast majority of the observations where collected in the time interval between October 19, 1998 to April 21, 2002 with the 1.0-m Ritchey-Chrétien telescope of the U. S. Naval Observatory, Flagstaff Station (Arizona). On average, UBVRcIc data are given on 3.6 epochs for each program star. The overall budget error of the data is usually better than 0.01 mag.

Key words: stars: pulsations – stars: variables – stars: AGB

1. INTRODUCTION

Symbiotic stars are binary systems composed of a cool giant and a hot compact companion (generally an accreting white dwarf). They show variability over any time scale from minutes (flickering) to several decades (outbursts of symbiotic novae), with phenomena related to the orbital motion having periodicities generally between 1 and 4 years (or up to a few decades in the systems harboring a Mira variable, ∼20% of all known symbiotic stars).

Therefore, the reconstruction of the photometric evolution of any given symbiotic star, involves combining data from different sources extending over the widest time interval. Given the generally variable and quite red colors of symbiotic stars, combining observations from many different sources would greatly benefit from the use of accurate, well established and common photometric sequences available around each symbiotic star.

We have established accurate UBVRcIc photometric comparison sequences around 83 mostly northern, symbiotic stars and related objects (Henden and Munari 2000, 2001, 2006). The sequences were intended to assist both current CCD photometry (therefore covering wide range in colors to firmly anchor the transformation from local to international photometric systems) as well as inspection of archival photographic plates (therefore covering, particularly in the B band, a large range in magnitude).

While establishing the photometric comparison sequences via CCD observa-

tions, we also recorded the corresponding symbiotic stars, and in this paper we report about their UBVRcIc magnitudes. The observations presented here were primarily obtained during the period from October 19, 1998 to April 21, 2002. Some PU Vul observations were obtained in 1995, some Z And observations occurred during 2003 and 2004, and we have included more recent observations of RS Oph and Z And.

A previous, multi-epoch photometric catalog of symbiotic stars was published by Munari et al. (1992). It contained data on 78 mostly southern objects, observed during 1990 in UBVRcIc from ESO and JHKL from SAAO, and in addition UBVRj and JHKL data of further 20 northern objects observed from Crimean Astrophysical Observatory from 1978 to 1989.

The present and Munari et al. (1992) catalogs therefore complements each other, and together they survey the majority of known symbiotic stars listed by Belczynski et al. (2000).

2. OBSERVATIONS

All of the observations from 2006 forward were acquired using the Sonoita Research Observatory (SRO) robotic 35cm telescope as part of a calibration and monitoring campaign. This telescope has a SBIG STL-1001E CCD camera with 1.25arcsec pixels and 20x20arcmin field of view. All prior observations (the vast majority of Table 1) were made with the 1.0m Ritchey-Chretíen telescope of the U.S. Naval Observatory, Flagstaff Station (NOFS). Two SITe/Tektronix thinned, backside illuminated CCDs were used, with 0.6763 arcsec/pixel telescope scale: a 1024x1024 format detector, yielding 11.4x11.4arcmin field of view, and a 2048x2048 CCD, with a 23x23 arcmin field of view. Typical seeing was 2arcsec. For both SRO and NOFS, images were processed using IRAF along with nightly median sky flats, dark and bias frames. Aperture photometry was performed whenever possible, while psf-fitting photometry was adopted in the case of blending of the symbiotic star with nearby field stars (e.g. UV Aur, V4074 Sgr). Inhomogenous photometry similar to Honeycutt (1992) was used for the final magnitude determination. The reported photometry only uses data collected on photometric nights (transformation errors under 0.02mag). For each such night, symbiotic field observations were interspersed with observations of Landolt (1983,1992) standard fields, selected for wide color and airmass range. See Henden and Munari (2000, 2001, 2006) for further details.

3. THE CATALOG

The photometric catalog is presented in Table 1, with the program stars listed in alphabetical order. There, HJD is the heliocentric Julian day minus 2400000, and refers to the UT middle of the V-band exposure. The listed errors are the Poissonian component of the total error budget. The total error budget is dominated by the transformation from the Landolt equatorial standard fields, which uncertainty does not in general exceed 0.02 mag.

The emphasis of Henden and Munari (2000, 2001, 2006) work was to calibrate the best possible photometric comparison sequences, not to go for the best measurement of the symbiotic stars. Consequently, for a few stars and for some of the

bands or observing epochs, the symbiotic star may be saturated or underexposed, and therefore will be missing from Table 1.

The observations collected on V1261 Ori were characterized by the star being always saturated at VRcIc. It was properly exposed only at U and B bands, and the corresponding data (not transformed for color equations) are presented in Table 2.

Table 1. Photometry of the symbiotic stars.

name	HJD	V		B-V		U-B		V-R$_c$		R$_c$-I$_c$	
AG Dra	52337.9564	9.813	0.001	1.340	0.002	0.319	0.002	0.870	0.001	0.636	0.003
AG Dra	52382.8642	9.829	0.001	1.376	0.001	0.412	0.002	0.874	0.001	0.670	0.002
AG Dra	52383.8746	9.826	0.001	1.383	0.001	0.425	0.003	0.860	0.001	0.689	0.002
AG Peg	52186.7081	8.769	0.001	1.260	0.001	−0.012	0.003	1.061	0.002	1.159	0.003
AG Peg	52286.5979	8.565	0.002	1.210	0.002	−0.290	0.003	1.013	0.003	1.085	0.004
AG Peg	52288.5591	8.588	0.000	1.178	0.000	−0.351	0.002	1.047	0.000	0.877	0.003
AG Peg	52292.5561	8.648	0.001	1.121	0.001	−0.343	0.002	0.950	0.002	0.970	0.003
ALS 1	51456.6970	13.518	0.002	1.381	0.003	0.329	0.008	1.156	0.002	1.373	0.002
ALS 1	51457.6891	13.516	0.002	1.376	0.003	0.318	0.005	1.158	0.001	1.377	0.001
ALS 1	51464.6866	13.428	0.002	1.409	0.003	0.295	0.005	1.147	0.003	1.354	0.001
ALS 2	51455.6396	14.324	0.004	1.899	0.007	0.529	0.025	1.374	0.004	1.211	0.005
ALS 2	51456.5950	14.335	0.004	1.890	0.007	0.469	0.014	1.373	0.005	1.227	0.003
ALS 2	51459.5961	14.302	0.005	1.882	0.011	0.546	0.024	1.346	0.004	1.229	0.004
ALS 2	51465.5988	14.315	0.005	1.905	0.010	0.428	0.025	1.393	0.005	1.228	0.005
ALS 2	51486.5555	14.332	0.008	1.913	0.023	0.523	0.069	1.370	0.008	1.269	0.009
Ap 3-1	51455.7309	17.008	0.036	2.026	0.084	0.929	0.155	2.153	0.038	2.178	0.013
Ap 3-1	51456.7230	17.024	0.044	2.125	0.105	0.572	0.158	2.139	0.046	2.200	0.015
Ap 3-1	51457.7087	17.026	0.023	2.072	0.062	0.685	0.099	2.125	0.024	2.243	0.009
AS 201	51999.6488	11.834	0.001	0.702	0.001	0.113	0.003	0.387	0.001	0.337	0.003
AS 201	52014.6273	11.835	0.001	0.690	0.002	0.117	0.003	0.385	0.001	0.327	0.003
AS 201	52016.6320	11.837	0.001	0.696	0.001	0.115	0.003	0.381	0.001	0.332	0.002
AS 210	52052.8452	12.123	0.003	1.482	0.004	−0.478	0.004	1.384	0.002	0.929	0.002
AS 210	52061.8452	12.225	0.002	1.409	0.004	−0.520	0.005	1.421	0.001	0.942	0.001
AS 210	52115.6991	12.617	0.003	1.127	0.006	−0.572	0.004	1.467	0.003	0.982	0.002
AS 289	52153.7092	12.700	0.002	1.621	0.004	−0.021	0.006	1.571	0.003	1.721	0.001
AS 289	52157.6347	12.687	0.002	1.608	0.004	−0.021	0.004	1.576	0.002	1.714	0.001
AS 289	52171.6437	12.691	0.002	1.612	0.003	−0.012	0.004	1.553	0.003	1.745	0.001
AS 323	51456.6747	14.215	0.006	0.964	0.009	−0.392	0.007	1.097	0.007	1.375	0.005
AS 323	51457.6401	14.212	0.005	0.994	0.006	−0.492	0.007	1.120	0.005	1.397	0.007
AS 323	51465.6534	14.145	0.006	1.013	0.007	−0.380	0.009	1.100	0.006	1.389	0.005
AS 327	52157.6667	12.861	0.002	1.571	0.005	0.244	0.008	1.265	0.004	1.115	0.003
AS 327	52171.5998	13.029	0.003	1.470	0.007	0.076	0.006	1.282	0.005	1.173	0.004
AS 327	52174.6254	13.031	0.003	1.471	0.005	0.052	0.007	1.283	0.004	1.162	0.003
AX Per	51873.6822	11.341	0.002	1.271	0.002	−0.380	0.004	1.321	0.002	1.520	0.001
AX Per	51877.6873	11.340	0.002	1.272	0.003	−0.383	0.004	1.310	0.004	1.331	0.005
AX Per	51906.6660	11.440	0.002	1.224	0.003	−0.504	0.004	1.320	0.002	1.547	0.001
BD Cam	52287.7223	8.732	0.001	1.138	0.002			0.661	0.002		
BF Cyg	52110.9205	12.441	0.002	0.804	0.004	−0.506	0.003	1.181	0.002	1.504	0.002
BF Cyg	52145.8160	12.595	0.002	0.747	0.003	−0.512	0.004	1.157	0.002	1.528	0.001
BF Cyg	52146.8206	12.586	0.002	0.729	0.003	−0.506	0.003	1.153	0.002	1.527	0.002
BF Cyg	52153.7988	12.648	0.002	0.716	0.003	−0.485	0.003	1.174	0.004	1.484	0.003
BX Mon	51581.7547	11.281	0.001	1.003	0.001	−0.441	0.001	1.057	0.002	1.489	0.002
BX Mon	51614.7060	11.235	0.001	1.162	0.001	−0.318	0.002	1.133	0.002	1.454	0.002
BX Mon	51629.7021	11.176	0.001	1.216	0.002	−0.351	0.002	1.150	0.001	1.452	0.002

Table 1. (continues).

name	HJD	V		B-V		U-B		V-R$_c$		R$_c$-I$_c$	
CH Cyg	52382.9451	7.560	0.003	1.679	0.002	0.878	0.002	1.766	0.002		
CH Cyg	52383.9103	7.565	0.002	1.688	0.001	0.869	0.002	1.694	0.002		
CH Cyg	52385.9986	7.650	0.002	1.660	0.001	0.869	0.001	1.643	0.001		
CI Cam	51220.7178	11.602	0.002	0.820	0.002						
CI Cam	51220.7203	11.604	0.002	0.808	0.001						
CI Cam	51222.7364	11.616	0.002	0.803	0.001						
CI Cam	51877.7400	11.725	0.001	0.793	0.002	−0.336	0.002	0.887	0.001		
CI Cam	51906.6750	11.718	0.002	0.809	0.002	−0.366	0.003	0.892	0.001	0.672	0.002
CI Cam	51930.6738	11.715	0.001	0.822	0.001	−0.284	0.004	0.889	0.002	0.693	0.001
CI Cyg	52110.9312	11.096	0.002	1.539	0.003	0.111	0.004	1.471	0.002	1.738	0.002
CI Cyg	52145.8798	11.240	0.001	1.390	0.002	−0.086	0.003	1.484	0.001	1.834	0.002
CI Cyg	52146.8590	11.256	0.001	1.390	0.002	−0.102	0.003	1.481	0.001	1.843	0.002
CM Aql	51455.7010	13.385	0.001	1.275	0.003	−0.260	0.005	1.148	0.001	1.207	0.003
CM Aql	51457.6682	13.347	0.002	1.262	0.003	−0.280	0.004	1.136	0.002	1.212	0.001
CM Aql	51464.6664	13.371	0.002	1.281	0.003	−0.301	0.003	1.146	0.002	1.222	0.002
DQ Ser	51729.7685	14.966	0.004	1.334	0.007	0.319	0.010	1.296	0.005	1.668	0.004
DQ Ser	51730.7943	14.943	0.003	1.343	0.006	0.291	0.010	1.305	0.004	1.630	0.004
DQ Ser	51731.7670	14.909	0.003	1.348	0.006	0.304	0.009	1.301	0.004	1.626	0.004
DT Ser	51728.8404	16.214	0.047	0.378	0.056	−0.832	0.033	−0.062	0.057	0.094	0.049
DT Ser	51729.8376	16.216	0.052	0.375	0.059	−0.821	0.032	−0.035	0.058		
DT Ser	51730.7814	16.210	0.047	0.361	0.053	−0.807	0.031	−0.067	0.056	−0.073	0.045
Draco C-1	51315.8097	17.118	0.006	1.450	0.013	−0.013	0.024	0.886	0.008	0.567	0.009
Draco C-1	51316.8076	17.096	0.005	1.473	0.010	−0.003	0.022	0.865	0.006	0.570	0.006
Draco C-1	51317.8164	17.081	0.005	1.496	0.010	0.028	0.025	0.830	0.006	0.589	0.006
EG And	52186.8091	7.241	0.002	1.605	0.002	1.676	0.005	0.838	0.003		
EG And	52287.7022	7.502	0.001	1.525	0.001	1.444	0.004				
EG And	52288.6575	7.463	0.000	1.474	0.002	1.518	0.006				
ER Del	51729.9051	10.354	0.001	1.765	0.002	1.170	0.003	1.173	0.002	1.478	0.002
ER Del	51730.9447	10.328	0.001	1.785	0.001	1.318	0.002	1.177	0.002	1.454	0.002
ER Del	51731.8077	10.308	0.001	1.797	0.002	1.356	0.003	1.170	0.002	1.453	0.002
FG Ser	51247.9919	11.872	0.001	1.683	0.002	−0.119	0.014	1.691	0.001	1.626	0.003
FG Ser	51251.9924	11.886	0.002	1.673	0.002	−0.169	0.003	1.597	0.002	1.554	0.001
FG Ser	51403.7917	11.633	0.001	1.755	0.002	−0.082	0.010	1.686	0.001	1.712	0.001
FG Ser	51465.6639	11.700	0.001	1.785	0.003	0.071	0.005	1.709	0.001	1.617	0.002
FG Ser	51487.5820	11.774	0.001	1.804	0.002	0.140	0.004	1.362	0.003	1.517	0.001
FN Sgr	51456.6244	12.075	0.002	0.717	0.002	−0.115	0.002	0.809	0.002	0.898	0.001
FN Sgr	51457.5924	12.120	0.002	0.737	0.003	−0.152	0.003	0.825	0.002	0.919	0.001
FN Sgr	51465.6147	12.116	0.004	0.731	0.001	−0.108	0.003	0.853	0.002	0.903	0.002
FN Sgr	51487.5651	12.005	0.002	0.713	0.002	−0.107	0.002	0.801	0.002	0.885	0.001
GH Gem	51581.7214	13.752	0.002	1.042	0.003	0.586	0.005	0.628	0.003	0.621	0.003
GH Gem	51613.8025	14.159	0.003	0.975	0.004	0.495	0.008	0.575	0.004	0.538	0.004
GH Gem	51614.7269	14.125	0.002	0.982	0.004	0.516	0.007	0.582	0.003	0.548	0.004
Hen 3-1341	51664.9078	11.325	0.003	0.506	0.001	−0.841	0.003	0.665	0.002	0.616	0.002
Hen 3-1341	51666.9428	11.361	0.001	0.557	0.001	−0.901	0.002	0.628	0.002	0.662	0.002
Hen 3-1341	51692.8582	11.376	0.001	0.523	0.001	−0.797	0.002	0.679	0.002	0.620	0.002
Hen 2-468	51402.8911	14.783	0.002	1.830	0.004	0.614	0.011	1.527	0.003	1.707	0.002
Hen 2-468	51403.8338	14.782	0.002	1.828	0.004	0.603	0.008	1.527	0.003	1.714	0.002
Hen 2-442	52145.8433	16.050	0.008	1.412	0.013	0.260	0.018	1.085	0.012	0.621	0.016
Hen 2-442	52171.7666	16.062	0.007	1.404	0.012	0.257	0.018	1.088	0.009	0.618	0.011
Hen 2-442	52174.7610	16.052	0.007	1.415	0.012	0.249	0.020	1.096	0.009	0.603	0.011
Hen 3-1342	52052.8568	13.422	0.003	1.821	0.005	0.278	0.008	1.192	0.004	1.046	0.003
Hen 3-1342	52061.8586	13.426	0.003	1.822	0.006	0.327	0.010	1.207	0.004	1.056	0.003
Hen 3-1342	52115.7371	13.418	0.004	1.876	0.005	0.776	0.009	1.186	0.004	1.107	0.003

Table 1. (continues).

name	HJD	V		B-V		U-B		V-R$_c$		R$_c$-I$_c$	
Hen 3-1591	52382.9707	13.186	0.004	1.217	0.004	0.598	0.007	0.747	0.004	0.704	0.005
Hen 3-1591	52383.9378	13.157	0.002	1.222	0.004	0.611	0.006	0.751	0.003	0.694	0.004
Hen 3-1591	52385.9625	13.075	0.002	1.217	0.004	0.587	0.005	0.728	0.003	0.695	0.004
HM Sge	52145.8347	11.749	0.002	0.812	0.003	−0.708	0.003	0.760	0.003	−0.122	0.004
HM Sge	52146.8303	11.756	0.002	0.810	0.003	−0.701	0.003	0.761	0.003	−0.128	0.004
HM Sge	52153.8074	11.746	0.002	0.816	0.003	−0.685	0.003	0.761	0.003	−0.142	0.004
IV Vir	51614.9327	10.757	0.001	1.440	0.002	0.673	0.005	0.830	0.001	0.732	0.002
IV Vir	51629.8606	10.687	0.001	1.399	0.002	0.544	0.003	0.809	0.002	0.737	0.002
IV Vir	51639.8596	10.681	0.001	1.390	0.002	0.403	0.003	0.809	0.002	0.724	0.001
K 3-9	51403.7401	16.971	0.007	1.289	0.012	0.552	0.031	0.838	0.011	0.961	0.017
K 3-9	51455.6808	16.914	0.013	1.313	0.022	0.482	0.051	0.880	0.020	1.000	0.027
K 3-9	51464.6390	16.980	0.009	1.288	0.015	0.425	0.044	0.853	0.014	0.947	0.021
LL Cas	51549.5720	15.968	0.013	0.886	0.018	−0.635	0.016	1.680	0.015	2.257	0.008
LL Cas	51550.5736	16.045	0.015	0.893	0.021	−0.663	0.019	1.737	0.017	2.248	0.008
LL Cas	51554.6255	16.011	0.010	0.902	0.014	−0.644	0.013	1.662	0.012	2.101	0.007
LT Del	51453.7393	13.064	0.001	1.264	0.002	−0.231	0.005	0.811	0.002	0.680	0.003
LT Del	51455.7588	13.057	0.002	1.270	0.003	−0.216	0.004	0.817	0.003	0.666	0.003
LT Del	51456.7591	13.061	0.001	1.271	0.002	−0.208	0.003	0.819	0.001	0.675	0.002
LW Cas	51554.7158	17.480	0.014	1.802	0.046			1.202	0.018	1.195	0.015
LW Cas	51577.7121	17.503	0.015	1.806	0.051			1.179	0.019	1.283	0.015
LW Cas	51874.6722	17.390	0.011	1.936	0.030			1.082	0.016	1.231	0.014
M 1-21	52052.9057	14.470	0.004	1.074	0.006	−0.316	0.006	1.671	0.005	1.469	0.004
M 1-21	52115.7581	14.714	0.005	1.093	0.007	−0.153	0.008	1.665	0.006	1.679	0.004
M 1-21	52145.6308	14.829	0.007	1.070	0.009	−0.181	0.010	1.671	0.007	1.672	0.004
MaC 1-17	52145.7650	15.182	0.005	1.624	0.010	−0.034	0.013	1.402	0.007	1.507	0.007
MaC 1-17	52157.7156	15.233	0.007	1.575	0.015	−0.123	0.021	1.441	0.008	1.460	0.006
MaC 1-17	52171.7069	15.039	0.005	1.645	0.009	−0.131	0.012	1.373	0.007	1.386	0.006
MWC 960	51105.5974	12.110	0.002	1.626	0.003						
MWC 960	51106.5818	12.122	0.001	1.623	0.002						
MWC 960	51349.8982	12.196	0.002	1.639	0.003	0.261	0.005	1.080	0.001	0.775	0.002
MWC 960	51352.8427	12.204	0.002	1.640	0.003	0.248	0.005	1.108	0.002	0.762	0.002
MWC 960	51465.5739	12.197	0.004	1.594	0.004	0.156	0.008	1.088	0.003	0.743	0.003
MWC 960	51486.5748	12.100	0.003	1.606	0.003	0.285	0.005	1.047	0.003	0.729	0.004
NQ Gem	52287.7964	8.133	0.000	1.900	0.002	2.529	0.003	0.974	0.002	0.636	0.000
NQ Gem	52288.7872	7.987	0.000	2.015	0.001	2.522	0.003	0.846	0.000	0.779	0.002
NQ Gem	52292.7095	7.935	0.001	2.045	0.002	2.539	0.004	0.865	0.000	0.985	0.002
NQ Gem	52292.7791	7.892	0.000	2.077	0.002	2.540	0.003	0.900	0.002	0.728	0.001
NSV 11776	51728.8702	13.473	0.003	0.921	0.003	−0.606	0.003	1.394	0.002	0.602	0.002
NSV 11776	51729.8508	13.473	0.003	0.920	0.003	−0.602	0.003	1.378	0.002	0.612	0.002
NSV 11776	51730.8298	13.472	0.002	0.917	0.003	−0.582	0.004	1.394	0.002	0.618	0.002
Pe 2-16	52157.6930	15.931	0.010	1.765	0.026	0.308	0.051	1.705	0.012	1.644	0.007
Pe 2-16	52171.6764	15.844	0.007	1.759	0.012	0.480	0.021	1.672	0.009	1.727	0.006
Pe 2-16	52174.6594	15.838	0.008	1.751	0.014	0.506	0.024	1.685	0.009	1.735	0.006
Pt 1	52145.6510	15.562	0.011	2.080	0.025	0.909	0.076	1.605	0.013	1.591	0.009
Pt 1	52146.6566	15.550	0.010	2.134	0.026	0.804	0.085	1.576	0.012	1.611	0.008
Pt 1	52153.6477	15.603	0.015	2.122	0.051	0.777	0.193	1.667	0.017	1.550	0.009
PU Vul	49990.7933	11.656	0.001	0.155	0.002						
PU Vul	49991.7948	11.657	0.002	0.143	0.002						
PU Vul	49992.6915	11.674	0.002	0.134	0.002						
PU Vul	51873.5997	11.749	0.001	0.323	0.001	−0.812	0.001	1.388	0.002	0.555	0.001
PU Vul	51877.6091	11.757	0.001	0.319	0.001	−0.800	0.001	1.357	0.001	0.601	0.002
PU Vul	51877.6186	11.764	0.005	0.306	0.007			1.386	0.006	0.577	0.004
PU Vul	52145.8961	11.829	0.001	0.388	0.002	−0.774	0.001	1.225	0.002	0.934	0.002

Table 1. (continues).

name	HJD	V		B-V		U-B		V-R$_c$		R$_c$-I$_c$	
QW Sge	51453.7213	12.572	0.004	0.972	0.005	−0.193	0.004	0.928	0.004	1.201	0.005
QW Sge	51455.7419	12.301	0.003	0.758	0.004	0.013	0.004	0.813	0.004	1.089	0.004
QW Sge	51456.7499	12.262	0.002	0.696	0.003	0.065	0.003	0.787	0.003	1.097	0.002
RS Oph	52382.9352	11.540	0.002	1.443	0.005			1.116	0.002	1.037	0.002
RS Oph	52383.9041	11.375	0.002	1.261	0.003	−0.073	0.003	1.030	0.002	1.032	0.001
RS Oph	52385.9522	11.238	0.002	1.223	0.003	0.059	0.003	0.990	0.002	0.998	0.002
RS Oph	53993.6153	11.628	0.003	1.513	0.005			1.065	0.004	0.657	0.002
RS Oph	53993.6218	11.626	0.003	1.527	0.005			1.186	0.005	0.609	0.002
RS Oph	53995.6550	11.485	0.003	1.596	0.005			1.237	0.005	0.959	0.005
RS Oph	53995.6628	11.477	0.004	1.594	0.006			1.213	0.008	0.992	0.005
RS Oph	53996.6114	11.406	0.002	1.615	0.009			1.193	0.005	0.959	0.006
RS Oph	53996.6193	11.415	0.003	1.595	0.006			1.220	0.006	0.953	0.006
RS Oph	53997.6143	11.395	0.004	1.595	0.006			1.218	0.004	0.956	0.006
RS Oph	53997.6204	11.406	0.003	1.582	0.006			1.206	0.006	0.970	0.006
RS Oph	54003.6142	11.498	0.005	1.531	0.005			1.184	0.006	1.022	0.007
RS Oph	54003.6221	11.484	0.005	1.487	0.005			1.189	0.007	1.021	0.007
RS Oph	54010.5971	11.572	0.004	1.349	0.006			1.157	0.006	1.080	0.007
RS Oph	54010.6049	11.586	0.004	1.361	0.006			1.180	0.005	1.047	0.005
RS Oph	54022.6085	11.528	0.004	1.380	0.007			1.167	0.007	1.095	0.009
RS Oph	54022.6167	11.611	0.023	1.330	0.024			1.256	0.033	1.004	0.035
RT Ser	52157.6166	14.734	0.005	1.367	0.009	0.067	0.012	1.890	0.006	1.809	0.003
RT Ser	52171.6237	14.929	0.004	1.249	0.006	−0.005	0.009	1.902	0.005	1.828	0.004
RT Ser	52174.6012	14.962	0.005	1.232	0.009	−0.019	0.011	1.916	0.006	1.844	0.004
RW Hya	52337.9123	8.805	0.002	1.380	0.002	−0.087	0.003	0.931	0.002	0.841	0.003
RW Hya	52382.8409	8.709	0.002	1.401	0.004	0.162	0.004	0.883	0.003	0.923	0.002
RW Hya	52383.8427	8.733	0.002	1.419	0.002	0.141	0.001	0.917	0.002	0.899	0.002
R Aqr	52186.7375	9.112	0.003	1.334	0.002	−0.668	0.006				
R Aqr	52288.5723	11.124	0.001	1.173	0.002	−0.602	0.004				
R Aqr	52292.5669	11.106	0.003	1.177	0.003	−0.592	0.002				
StHα 149	51694.8565	12.089	0.002	1.538	0.001	0.618	0.003	1.117	0.002	1.360	0.001
StHα 149	51695.8420	12.109	0.001	1.542	0.002	0.628	0.004	1.140	0.001	1.328	0.002
StHα 149	51728.8013	11.980	0.001	1.576	0.002	0.704	0.004	1.122	0.001	1.294	0.002
StHα 164	51728.8973	14.455	0.002	2.047	0.006	1.293	0.032	1.490	0.003	1.729	0.003
StHα 164	51729.8674	14.481	0.003	2.026	0.008	1.228	0.028	1.488	0.004	1.754	0.003
StHα 164	51730.8442	14.492	0.003	2.016	0.008	1.283	0.027	1.508	0.004	1.732	0.002
StHα 169	52110.9392	13.742	0.002	1.638	0.004	0.890	0.008	1.056	0.003	1.099	0.003
StHα 169	52145.8670	13.642	0.002	1.634	0.004	0.989	0.009	1.026	0.003	1.101	0.003
StHα 169	52146.8374	13.647	0.002	1.645	0.004	0.978	0.008	1.032	0.003	1.096	0.003
StHα 180	51728.9135	12.667	0.001	1.409	0.002	0.121	0.004	0.921	0.001	0.873	0.002
StHα 180	51729.8912	12.681	0.001	1.398	0.002	0.124	0.004	0.923	0.001	0.885	0.002
StHα 180	51730.9055	12.676	0.001	1.400	0.002	0.114	0.004	0.923	0.001	0.877	0.002
StHα 190	51729.9165	10.527	0.002	0.836	0.002	−0.239	0.002	0.496	0.002	0.479	0.002
StHα 190	51730.9527	10.500	0.001	0.840	0.001	−0.225	0.002	0.491	0.001	0.468	0.002
StHα 190	51731.8393	10.484	0.001	0.837	0.002	−0.215	0.002	0.498	0.001	0.474	0.002
StHα 32	51515.7193	12.781	0.002	1.462	0.004	−0.378	0.005	0.778	0.004	0.593	0.004
StHα 32	51528.7647	12.810	0.001	1.437	0.002	−0.389	0.003	0.787	0.002	0.599	0.005
StHα 32	51547.6590	12.706	0.001	1.448	0.001	−0.240	0.003	0.757	0.001	0.605	0.002
StHα 32	51548.6358	12.708	0.001	1.453	0.002	−0.222	0.003	0.765	0.002	0.589	0.003
StHα 32	51549.6589	12.706	0.001	1.455	0.002	−0.212	0.003	0.763	0.001	0.600	0.001
TX CVn	51614.8067	10.092	0.003	0.691	0.002	0.130	0.004	0.647	0.003	0.748	0.002
TX CVn	51629.8527	10.040	0.002	0.708	0.001	0.117	0.007	0.629	0.004	0.765	0.003
TX CVn	51639.8016	10.170	0.002	0.659	0.002	0.069	0.007	0.561	0.003	0.917	0.003
T CrB	52382.8510	10.073	0.001	1.402	0.001	0.536	0.003	1.088	0.002	1.458	0.001
T CrB	52383.8649	10.091	0.001	1.406	0.002	0.535	0.004	1.080	0.002	1.495	0.004
T CrB	52385.9104	10.177	0.003	1.423	0.002	0.658	0.002	1.102	0.001	1.515	0.003

Table 1. (continues).

name	HJD	V		B-V		U-B		V-R$_c$		R$_c$-I$_c$	
UKS Ce1	51664.8863	15.639	0.005	1.460	0.011						
UKS Ce1	51692.8099	15.872	0.010	1.854	0.021			1.006	0.013	0.834	0.011
UKS Ce1	51693.8293	15.886	0.011	1.839	0.022	1.127	0.094	1.047	0.014	0.800	0.012
UU Ser	51692.8722	15.474	0.006	1.776	0.013	2.456	0.128	0.980	0.008	0.890	0.007
UU Ser	51693.8563	15.474	0.006	1.778	0.014	2.156	0.092	0.984	0.008	0.890	0.007
UU Ser	51695.8653	15.461	0.005	1.813	0.012	2.323	0.105	0.969	0.007	0.891	0.007
UV Aur	52186.9209	9.508	0.007	3.890	0.046	2.131	0.117				
UV Aur	52287.7649	11.054	0.011	5.165	0.065	1.752	0.258				
UV Aur	52288.7382	11.064	0.015	4.908	0.157						
V1016 Cyg	52145.8875	11.261	0.001	0.426	0.002	−0.901	0.002	1.031	0.001	−0.101	0.002
V1016 Cyg	52146.8650	11.263	0.001	0.414	0.002	−0.893	0.001	1.039	0.001	−0.121	0.002
V1016 Cyg	52153.8122	11.260	0.002	0.425	0.002	−0.882	0.002	1.041	0.002	−0.083	0.002
V1329 Cyg	51873.6384	13.193	0.002	0.681	0.003	−0.770	0.003	1.376	0.002	1.097	0.002
V1329 Cyg	51877.6264	13.195	0.002	0.664	0.003	−0.788	0.003	1.363	0.003	1.066	0.002
V1329 Cyg	51906.5564	13.102	0.002	0.694	0.004	−0.929	0.004	1.388	0.003	1.144	0.002
V1413 Aql	51453.7053	13.222	0.003	0.945	0.003	0.044	0.004	0.929	0.003	1.149	0.003
V1413 Aql	51457.7294	13.073	0.003	0.960	0.003	0.040	0.004	0.928	0.004	1.094	0.005
V1413 Aql	51464.7005	12.987	0.004	0.979	0.004	0.038	0.003	0.918	0.005	1.099	0.005
V335 Vul	51349.9180	12.901	0.003	5.125	0.017			1.996	0.002	1.460	0.001
V335 Vul	51352.8235	12.865	0.003	5.096	0.026			2.007	0.002	1.450	0.001
V335 Vul	51398.8497	11.976	0.001	4.671	0.006			1.669	0.002	1.283	0.002
V335 Vul	51402.8674	11.957	0.001	4.602	0.005			1.641	0.001	1.122	0.002
V335 Vul	51515.5501	11.310	0.004	3.055	0.005			1.452	0.001	1.276	0.001
V352 Aql	52153.7688	16.696	0.023	1.678	0.077	0.352	0.216	1.795	0.025	1.739	0.012
V352 Aql	52171.7364	16.555	0.011	1.776	0.027	0.540	0.055	1.729	0.013	1.714	0.007
V352 Aql	52174.7022	16.569	0.011	1.763	0.027	0.481	0.053	1.750	0.013	1.714	0.007
V4018 Sgr	52051.9292	13.144	0.004	1.086	0.004						
V4018 Sgr	52146.6819	13.359	0.003	1.087	0.005	−0.441	0.005	1.147	0.004	1.483	0.003
V4018 Sgr	52153.6860	13.336	0.004	1.087	0.007	−0.383	0.009	1.187	0.005	1.397	0.004
V4018 Sgr	52157.6502	13.318	0.003	1.101	0.006	−0.393	0.007	1.169	0.004	1.401	0.003
V407 Cyg	51316.9262	11.755	0.001	1.522	0.001	0.112	0.002	1.934	0.002	2.193	0.002
V407 Cyg	51317.9619	11.685	0.001	1.482	0.001	0.012	0.002	1.845	0.001	1.801	0.002
V407 Cyg	51318.9649	11.570	0.001	1.456	0.001	0.052	0.002	1.804	0.001	2.204	0.003
V4074 Sgr	52382.9889	13.802	0.051					1.058	0.057	1.545	0.033
V4074 Sgr	52383.9625	13.871	0.047					1.082	0.055	1.531	0.041
V4074 Sgr	52385.9939	13.684	0.045					1.032	0.059	1.423	0.046
V4368 Sgr	51728.8271	10.536	0.002	0.657	0.002	0.019	0.001	0.373	0.003	0.446	0.002
V4368 Sgr	51729.8203	10.616	0.002	0.619	0.001	0.019	0.002	0.421	0.004	0.414	0.004
V4368 Sgr	51730.8205	10.574	0.001	0.626	0.001	0.048	0.001	0.383	0.002	0.433	0.002
V443 Her	51315.9769	11.362	0.002	1.061	0.003	−0.420	0.003	1.302	0.003	1.525	0.002
V443 Her	51316.9094	11.369	0.002	1.054	0.003	−0.428	0.003	1.301	0.003	1.507	0.001
V443 Her	51318.8944	11.386	0.002	1.054	0.003	−0.422	0.004	1.295	0.002	1.537	0.002
V503 Her	51694.8318	12.692	0.002	1.216	0.002	0.851	0.004	0.704	0.002	0.716	0.001
V503 Her	51695.8099	12.691	0.001	1.222	0.002	0.857	0.004	0.702	0.001	0.714	0.001
V503 Her	51728.7907	12.635	0.001	1.391	0.002	1.211	0.004	0.781	0.001	0.721	0.001
V627 Cas	51402.9163	12.882	0.001	2.595	0.003	1.159	0.008	2.132	0.001	2.098	0.002
V627 Cas	51403.8571	12.863	0.001	2.604	0.003	1.173	0.007	2.123	0.001	2.114	0.002
V627 Cas	51453.7941	12.535	0.001	2.680	0.003	1.071	0.007	2.052	0.001	2.012	0.003
V694 Mon	51614.7186	10.876	0.001	0.425	0.002	−0.325	0.005	0.776	0.002	1.488	0.001
V694 Mon	51629.7111	10.877	0.001	0.490	0.002	−0.400	0.003	0.807	0.002	1.483	0.002
V694 Mon	51639.6293	10.676	0.001	0.436	0.002	−0.363	0.002	0.713	0.001	1.409	0.002
V471 Per	51515.6763	13.088	0.001	0.986	0.001	0.041	0.002	0.762	0.002	0.385	0.004
V471 Per	51549.7426	13.093	0.001	0.999	0.002	0.040	0.004	0.763	0.002	0.373	0.004
V471 Per	51550.7318	13.099	0.002	0.997	0.003	0.015	0.003	0.767	0.004	0.373	0.004

Table 1. (continues).

name	HJD	V		B-V		U-B		V-R$_c$		R$_c$-I$_c$	
V919 Sgr	51456.6430	13.023	0.003	1.196	0.004	−0.328	0.003	1.302	0.003	1.462	0.002
V919 Sgr	51457.6074	13.012	0.003	1.190	0.002	−0.350	0.005	1.291	0.001	1.472	0.001
V919 Sgr	51465.6320	12.928	0.004	1.221	0.004	−0.260	0.004	1.285	0.004	1.441	0.003
V934 Her	52382.8879	7.635	0.002	1.606	0.001	1.837	0.005	0.896	0.003	1.044	0.002
V934 Her	52383.8863	7.633	0.002	1.611	0.001	1.914	0.003	0.896	0.002	1.052	0.001
V934 Her	52385.9454	7.643	0.003	1.614	0.001	1.900	0.001	0.956	0.002	1.122	0.001
Wray 15-1470	52052.8286	13.408	0.002	0.745	0.004	−0.630	0.006	1.520	0.003	0.947	0.001
Wray 15-1470	52061.8293	13.464	0.003	0.722	0.005	−0.664	0.008	1.529	0.002	0.960	0.002
Wray 15-1470	52115.6868	13.215	0.002	0.853	0.004	−0.564	0.006	1.472	0.004	0.958	0.004
Wray 15-157	51999.6359	13.400	0.003	1.440	0.007	0.686	0.012	0.856	0.005	0.747	0.005
Wray 15-157	52014.6136	13.552	0.007	1.471	0.020	0.675	0.044	0.870	0.009	0.763	0.008
Wray 15-157	52016.6184	13.569	0.007	1.465	0.017	0.712	0.033	0.867	0.009	0.750	0.008
YY Her	51729.7533	12.934	0.001	1.373	0.002	0.013	0.004	1.073	0.001	1.293	0.001
YY Her	51730.7664	12.922	0.001	1.373	0.002	0.024	0.004	1.088	0.001	1.252	0.001
YY Her	51731.7535	12.919	0.001	1.380	0.002	0.029	0.004	1.087	0.001	1.259	0.001
ZZ CMi	52186.9821	9.974	0.001	1.457	0.001	0.626	0.003	1.628	0.002		
ZZ CMi	52287.7843	9.826	0.000	1.336	0.001	0.960	0.001	1.410	0.000	1.629	0.000
ZZ CMi	52288.7767	9.742	0.000	1.412	0.001	1.009	0.001	1.405	0.000		
Z And	52186.7214	9.666	0.002	0.675	0.001	−0.817	0.003	0.892	0.002	1.040	0.002
Z And	52288.6288	9.960	0.002	0.680	0.002	−0.800	0.002	0.868	0.001	1.013	0.001
Z And	52292.6282	10.026	0.000	0.719	0.001	−0.799	0.002	0.994	0.000	1.126	0.002
Z And	52566.6292	10.066	0.003	0.892	0.004	−0.549	0.005				
Z And	53251.6659	9.193	0.004	0.620	0.006	−0.394	0.004	0.767	0.002	0.918	0.003
Z And	53293.8157	9.399	0.005	0.655	0.003			0.804	0.011	1.015	0.007
Z And	54476.6710	9.355	0.002	0.608	0.004			0.700	0.004	0.801	0.005
Z And	54476.6731	9.362	0.004	0.604	0.003			0.660	0.003	0.711	0.005
Z And	54477.5773	9.399	0.003	0.705	0.004			0.800	0.005	0.688	0.003
Z And	54477.5795	9.448	0.003	0.665	0.005			0.802	0.004	0.730	0.003
Z And	54479.5757	9.501	0.004	0.683	0.006			0.912	0.005	0.751	0.003
Z And	54479.5778	9.501	0.003	0.686	0.006			0.900	0.004		
Z And	54480.6245	9.628	0.004	0.672	0.005			0.971	0.006	0.899	0.004
Z And	54480.6265	9.628	0.003	0.666	0.005			0.986	0.005	0.883	0.003
Z And	54484.5734	9.612	0.006	0.666	0.005			0.806	0.005	0.721	0.004
Z And	54484.5762	9.662	0.005	0.616	0.005			0.774	0.006	0.839	0.006

Table 2. Data for V1261 Ori.

52186.9578	B= 8.607	0.001
52186.9604	U=10.250	0.003
52287.7433	B= 8.836	0.002
52287.7454	U=10.095	0.004
52288.7302	B= 8.707	0.002
52288.7324	U=10.116	0.003

REFERENCES

Belczynski K., Mikolajewska J., Munari U., Ivison R. J., Friedjung M. 2000, A&AS 146, 407

Henden A., Munari U. 2000, A&AS 143, 343

Henden A., Munari U. 2001, A&A 372, 145

Henden A., Munari U. 2006, A&A 458, 339

Honeycutt R. K. 1992, PASP 104, 435

Landolt A. U. 1983, AJ 88, 439

Landolt A. U. 1992, AJ 104, 340

Munari U., Yudin B. F., Taranova O. G., Massone G., Marang F., Roberts G., Winkler H., Whitelock P. A. 1992, A&AS 93, 383